U.S. Department of Transportation
Federal Aviation Administration

Subject:	INFORMATION: Policy Statement with respect to All Electrical Attitude, Altitude, Direction and Airspeed Systems using Battery Standby Power	Date:	APR 27 2001
From:	Manger, Transport Airplane Directorate, Standards Staff, ANM-110	Reply to Attn. of:	00-111-159
To:	See Distribution	Regulatory Reference:	§§ 25.1333, 25.1309

The purpose of this memorandum is to clarify Federal Aviation Administration (FAA) certification policy with respect to All Electrical Attitude, Altitude, Direction and Airspeed Systems using Battery Standby Power. With the advent of highly reliable, low power, Liquid Crystal Display (LCD) electrical indicators, applicants are replacing previous pneumatic indicators with electric ones, resulting in an all electric attitude, altitude, direction or airspeed configuration. Many of these installations rely on time-limited batteries to power the instruments in the event of loss of generator power on the airplane. Such all electric configurations must be designed to ensure continued safe flight and landing after any failure or combination of failures not shown to be extremely improbable, including the loss of generated electrical power.

Current Regulatory and Advisory Material

It is FAA policy that a substantial change in an aircraft system design requires compliance with the related airworthiness rules in effect at the time of application for certification. Changing an attitude, direction, altitude, or airspeed system powered by dissimilar (e.g. pneumatic versus electrical) power sources to an all electric configuration constitutes a substantial redesign of the system, for which the FAA requires compliance with FAR § 25.1333, Amendment 25-23.

FAR § 25.1333(b) requires that at least one display of information essential for safe flight and landing, which is provided by the instruments, including attitude, direction, altitude, and airspeed, remain available after any single failure or combination of failures not shown to be extremely improbable. This requirement is consistent with the system safety standards of § 25.1309 for ensuring continued safe flight and landing. For an all-electric attitude, direction, altitude, or altimeter system, this means that backup electrical power must be available to ensure continued safe flight and landing, commensurate with the operational requirements of the airplane. In other words, to provide continued safe flight and landing, the instrument functions must be provided until the airplane is safely landed. The minimum period of time that the time-limited backup power will be needed to power at least on set of flight instruments until a safe landing can be performed must be established, taking into account the intended operation of the airplane.

Extended range operation over water and remote areas of the world (i.e. where suitable runways are relatively distant), IFR operations and the length of time needed to safely land after loss of normally generated power are all operational factors to be considered in determining the minimum endurance of the backup power.

An FAA rule for commercial operators, FAA § 121.305(k), requires 30 minutes of reliable operation from a power source, independent of the electrical generation system, for the third attitude instrument. This regulation is the direct result of the 1969 accident of a United Airlines Boeing Model 727-22C which crashed into Santa Monica Bay at night after takeoff from LAX. The airplane was dispatched with one generator inoperative and a fire warning in the number one engine was reported. The fire resulted in the loss of all electrical power to the flight instruments, particularly the attitude displays.

FAR § 25.1351(d) requires that the airplane be capable of operating safely for at least 5 minutes in VFR conditions with the normal electrical generation system inoperative. However, mere compliance with FAR, § 121.305 and/or 25.1351, will not ensure that essential flight instruments can continue to operate long enough for a safe landing to be accomplished, as required by § 25.1333 (b).

Unlike FAR, § 25.1351(d), Joint Aviation Regulation (JAR) ACJ 25.1351(d) states that provision should be made to ensure that adequate electrical power exists to complete the flight and make a safe landing. The ACJ further states that, unless a shorter duration is shown to be adequate, time limited sources (i.e. batteries) should have a minimum operational endurance of 60 minutes. An ARAC working group has recommended a revision to FAA Advisory Circular AC 25.1351-1 to add a 60 minute battery endurance requirement for Instrument Meteorological Conditions (IMC) after loss of normal aircraft electrical power sources. The recommended revision would also require that airplanes be able to fly safely to a suitable alternate airport after the loss of all normal aircraft electrical power sources.

There are two Transport Airplane Directorate (TAD) policy memoranda regarding the issue of all-electrical altimeter installations, dated June 20, 1995, and August 19, 1968. Both these memoranda address the replacement of pneumatic altimeters with electrically powered altimeters. In both cases, the FAA position was to not approve an all-electric altimeter installation, due to insufficient reliability of the electrical power systems.

Relevant Past Practice

A review of recent all-electric altimeter STC approvals indicates that the FAA approved several installations to certain criteria which exceeded the original certification basis of the airplane, but which may not have complied with the current airworthiness regulations. Often, the original certification basis of the airplane predates FAR § 25.1333, Amendment 25-23, which requires that one display of the information essential to the safety of flight provided by the instruments, including altitude, direction, airspeed, and altitude, will remain available to the pilots after any single failure, or combination of failures, that is not shown to be extremely improbable. The limiting factor in showing compliance is often the reliability of the electrical power generating system.

For most transport category airplanes, it is very challenging to establish that the electrical power generating system is so reliable that its loss is extremely improbable. System safety analyses which attempt to show that the loss of all electrical generator power is extremely improbable require careful examination to determine the potential for common cause and cascade failures. Electrical generators driven by an Auxiliary Power Unit (APU) cannot be counted on for in-flight back-up power due to the typical problems of starting such units in-flight after being cold soaked at altitude. There have been numerous instances of complete loss of normal electrical power. These were caused by a variety of circumstances, including crew errors and cascading effects of a single failure, that were not foreseen nor accounted for in a safety analysis.

Hence, the installation of an all-electrical attitude, altitude, airspeed or direction instruments typically leads to the need for reliable backup electrical power, which is usually a time-limited battery, unless an independent generator, such as a ram air turbine-powered generator is installed. For some recent approvals, a 30 minute battery power capability, after the loss of all generated electrical power, was considered acceptable for the standby instruments, but for other recent approvals, the FAA has required one or more hours of battery power for such instruments. In typical transport airplane operations, it can take more than 30 minutes to descend, reach a suitable airport, and land safely. Visual meteorological conditions (VMC) cannot be assumed to exist during all emergencies. Increased terminal congestion, extended over-water operation (ETOPS and non-ETOPS), and airplane operating altitudes in excess of 35,000 feet require that essential flight instruments be capable of operating for periods greater than 30 minutes to ensure continued safe flight and landing. Furthermore, the battery operating capacity must be sufficient to account for a cold-soaked airplane, in which the extremely cold operating conditions may significantly reduce the battery's operational endurance.

Policy

Based on the above information, the following eight guidelines should be used for the certification of flight instrument installations in which all displays of any of the essential flight information (e.g. altitude, attitude, airspeed or direction) require electrical power, the failure of normal electrical power is not extremely improbable and the back up source of electrical power is a time-limited battery:

1. Ensure that the requirements of FAR § 25.1333, at Amendment level 25-23 or higher, are incorporated into the certification basis. For supplemental type certificate projects and amended type certificate projects, an issue paper should be prepared to update the certification basis for the new design.

2. In determining the minimum length of time that at least one display of information essential to flight safety (e.g. attitude, altitude, and airspeed) must be operating, the required battery power must be sufficient to allow the flight crew to descend, reach a suitable airport, and land. The proposed source of backup electrical power should have sufficient operational endurance to provide electrical power for at least one display of attitude, altitude and airspeed for the total length of time required for the flight diversion, plus a margin of safety of an additional 30 minutes to account for unforeseen operational delays at the diversion airport. For domestic, over-land operations, unless a shorter duration can be shown to be adequate, 60 minutes should be the minimum required duration of backup battery power.

3. For transport airplanes capable of extended operations over water or over remote, runway sparse areas of the world, 60 minutes may not be enough time to reach a suitable airport and land safely. An acceptable method would be to apply ETOPS criteria, as outlined in AC 120-42A, paragraph 8c(4), to these airplanes and then assume that generator power is lost at the maximum possible distance from a suitable airport. Again, the time-limited backup power should last the total length of time required for the flight diversion, plus a margin of safety of an additional 30 minutes to account for unforeseen operational delays at the diversion airport.

4. Due to the possible resistance inherent in the actual aircraft wiring installation, and the additional internal resistance of rechargeable batteries, the capability of the backup battery to provide adequate power for the required minimum duration should be demonstrated by actual testing.

5. The same battery used to provide backup power for the essential flight instruments might also be used for other essential loads (e.g. pitot heat, communications, navigation, etc.) and to start the auxiliary power unit (APU) or to re-start the engines in flight. In such installations, the time-limited backup power source

must have the capacity to operate these essential information displays, and the other essential loads as applicable, for the required minimum flight duration, described in items 1 and 2 above, after being used in at least three unsuccessful attempts to start an engine or APU, as applicable to the design. This capability should be demonstrated by actual test.

6. Extremely cold operating conditions can significantly reduce battery endurance, therefore the backup battery must be demonstrated to have sufficient electrical capacity to account for the effects of a cold-soaked airplane.

7. Instructions for continued airworthiness for the backup battery should be included in the design approval. These instructions should ensure that adequate battery power is available between maintenance cycles. Unless an average charge state for the battery, of less than 100%, is assumed at the beginning of each flight, there must be a means for the flight crew or maintenance personnel to determine the actual battery charge state prior to takeoff.

8. The FAA Approved Airplane Flight Manual (AFM), or AFM Supplement for the installation, if applicable, should state in the Limitations section that the airplane must not be flown beyond reach of a suitable runway, such that a diversion, descent and safe landing can be conducted, including a 30 minute margin of safety, within the shortest length of time the backup battery can supply the essential flight instruments and other essential loads, as applicable, after loss of normal electrical power. The minimum demonstrated endurance of the backup battery, considering the conditions stated in the preceding guidelines, must be stated in the AFM.

Finally, it should also be noted that, although some FAA design approvals of all-electric altimeter installations have been subsequently found to not meet the current FAR § 25.1333 requirements, there have been no reported safety incidents associated with these installations. ACO engineers should consult the Reduced Vertical Separation Minimum (RVSM) requirements before approving installations of all-electric altimeter systems which do not meet the flight critical requirements as outlined in § 25.1333(b).

The Effect of Policy

The general policy stated in this document is not intended to establish a binding norm; it does not constitute a new regulation and the FAA would not apply or rely upon it as a regulation. The FAA Aircraft Certification Offices (ACO) that certify transport category airplanes should generally attempt to apply this policy, when appropriate; but in determining compliance with certification standards, each ACO has the discretion not to apply these guidelines where it determines that they are inappropriate. However, whenever proposing to deviate from these guidelines, the ACO should generate an issue paper and coordinate it with the Transport Airplane Directorate (TAD) to ensure standardization.

Applicants should expect that the certificating officials will consider this information when making findings of compliance relevant to new certificate actions. Also, as with all advisory material, this statement of policy identifies one means, but not the only means, of compliance.

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Standards Staff

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